

## Original article

# Does severity of femoral trochlear dysplasia affect outcome in patellofemoral instability treated by medial patellofemoral ligament reconstruction and anterior tibial tuberosity transfer?



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## ABSTRACT

**Introduction:** Medial patellofemoral ligament (MPFL) reconstruction associated to anterior tibial tuberosity transfer (ATTT) is recommended in objective patellofemoral instability (PFI). Efficacy, however, has not been precisely determined in trochlear dysplasia with spur. A case-control study was performed in a PFI population, comparing groups with trochlear dysplasia with and without spur (S+ vs. S−) to assess the impact of trochlear dysplasia on (1) patellofemoral stability, (2) functional results and complications, and (3) patellofemoral cartilage status on MRI.

**Hypothesis:** Trochlear spur does not affect outcome in PFI managed by MPFL reconstruction and ATTT. **Material and methods:** Twenty-eight knees (26 patients) with PFI were analyzed retrospectively and divided into 2 groups of 14 knees each according to presence of trochlear spur (S+ vs. S−). All 28 knees had undergone ATTT and MPFL reconstruction by semitendinosus autograft. Results were assessed on Lille and IKDC functional scores, and cartilage status was determined on MRI at last follow-up.

**Results:** At a mean 24 months' follow-up (range, 12–52 months), there was no recurrence of dislocation. IKDC and Lille scores tended to improve in both groups, although the only significant improvement was in IKDC score (S− gain,  $21.3 \pm 16$ ; S+ gain,  $18.1 \pm 14$ ) ( $P=0.01$ ). IKDC scores at last follow-up were better in the S+ than S− group ( $79 \pm 19$  [range, 21–92] vs.  $68 \pm 13$  [range, 35–84], respectively;  $P=0.012$ ). Lille scores showed no significant inter-group differences in mean gain ( $P=0.492$ ) or mean value ( $P=0.381$ ). The S+ group showed more cartilage lesions ( $n=14/14$  knees, including 12/14 with grade  $\geq 2$  lesions) than the S− group ( $n=9/14$  knees, all grade  $\leq 2$ ).

**Conclusion:** MPFL reconstruction with ATTT provided good short-term patellofemoral stability independently of the severity of trochlear dysplasia. Functional results and gain on IKDC, however, were poorer in case of dysplasia with trochlear spur. This is probably due to cartilage lesions, observed more frequently pre- and post-operatively in the spur group, especially as there was no significant difference in Lille Score, which highlights stability.

**Level of evidence:** III, retrospective case-control study.

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## 1. Introduction

Trochlear dysplasia is one of the main anatomic factors in patellofemoral instability (PFI) [1]. Supratrochlear spurs distinguish severity grades [1]: dislocating dysplasia (high grade: B and

D, with spur) and non-dislocating dysplasia (low grade: A and C, without spur) [2].

Surgical management of high-grade trochlear dysplasia is controversial. A meta-analysis by Song et al. [3] found comparable clinical results in dysplasia with spur between patients treated by trochleoplasty versus other procedures: medial patellofemoral ligament (MPFL) reconstruction, anterior tibial tuberosity transfer (ATTT), etc. Sulcus-deepening trochleoplasty is technically demanding [3] and incurs a risk of long-term cartilage lesion [4]; we, like others, therefore prefer less invasive stabilization

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techniques, and notably MPFL reconstruction. Soft-tissue surgery, however, fails to correct trochlear dysplasia or to remove spurs. A case-control study was therefore performed on PFI patients undergoing MPFL reconstruction with ATTT, comparing groups with and without trochlear spur (S+ vs. S–, respectively), to assess the impact of dysplasia severity on:

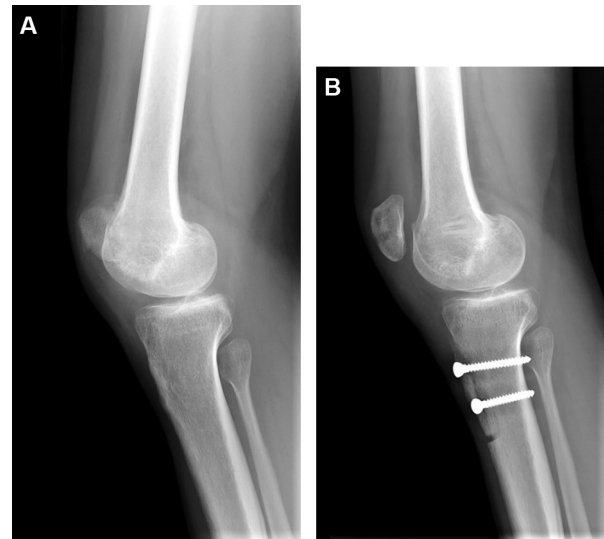
- patellofemoral stability;
- functional results and complications;
- patellofemoral cartilage status on MRI.

The hypothesis was that severity of trochlear dysplasia does not affect results in PFI treated by MPFL reconstruction and ATTT.

## 2. Material and methods

### 2.1. Patients

A continuous single-center series of 31 knees in 28 PFI patients undergoing MPFL reconstruction with ATTT between January 2008 and May 2012 was analyzed retrospectively. Two patients were excluded for incomplete data. Twenty-eight knees (26 patients) were therefore included, with a minimum 12 months' follow-up (clinical follow-up rate, 89.3%). Mean age at surgery was  $26.57 \pm 7.22$  years (range, 15–50 years). One knee had had previous arthroscopic lateral patellar wing sectioning. Patients were divided between 2 groups of 14 knees each (Table 1): the S– group (without spur) comprised patients without trochlear dysplasia ( $n = 5$ ) or with grade A or C dysplasia ( $n = 9$ : 8 grade A, 1 grade C) on the Dejour classification [2]; the S+ group (with spur) comprised patients with grade B or D dysplasia ( $n = 14$ : 8 grade B, 6 grade D) (Fig. 1). The two groups were comparable on all criteria (Table 1), except for cartilage lesions, which were more frequent preoperatively in the S+ group ( $P < 0.01$ ). MPFL reconstruction was indicated for PFI resistant to  $\geq 6$  months' medical treatment, and was performed by semitendinosus autograft with overlapping suture through two transpatellar tunnels, following Davis and Fithian [7]. The femoral tunnel was positioned on the radiographic criteria of Schöttle et al. [8] (Fig. 2), under intraoperative radioscopic control. Femoral fixation used an interference screw. Tension was set at 30° flexion. All surgery was performed under the supervision of one senior surgeon (GP). Isolated ATT distalization was performed ( $n = 14$ ) in case of patella alta (Caton-Deschamps Index  $> 1.2$ ). The ATT was medialized ( $n = 7$ ) in case of excessive extensor system lateralization (AT-TG distance  $> 20$  mm). ATT transfer was distal and medial ( $n = 7$ ) in case of combined abnormality (Table 1). Postoperative rehabilitation (3–5 sessions per week) was standardized and identical in both groups: weight-bearing with forearm crutch and removable splint for 30–45 days; passive range of motion exercises up to 90° flexion for the first 45 days and then without restriction; after 2



**Fig. 1.** Radiographs of a 24 year-old woman with grade B dysplasia (group S+, with trochlear spur) treated by MPFL reconstruction and ATTT. 1A: preoperative strict lateral view in 30° flexion. 1B: lateral view in 30° flexion at 32 months' follow-up after MPFL reconstruction.



**Fig. 2.** Positioning of “isometric” femoral tunnel, following Schöttle et al. [16].

weeks, “aided active” quadriceps and hamstring exercises; then active closed-chain exercises for 3 months, followed by open-chain exercises.

### 2.2. Assessment

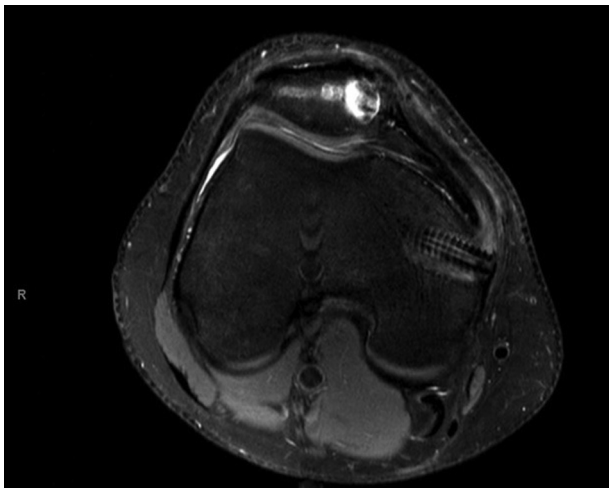
Minimum follow-up was 1 year, and mean follow-up 24 months (range, 12–52 months). All patients had functional assessment preoperatively and at follow-up, comprising 2 self-assessment questionnaires: Lille clinical score [5] for patellar stability, and subjective IKDC score [6] for function. Preoperative clinical scores were comparable between groups: slightly but not significantly better in the S– group (Table 1).

Follow-up screened for recurrence of dislocation and subjective instability. Satisfaction was self-assessed as satisfied/very satisfied versus disappointed/dissatisfied. Complications [9] and revision surgeries were noted. A Smillie apprehension test was performed.

**Table 1**  
Preoperative clinical data per group.

	S– group ( $n = 14$ )	S+ group ( $n = 14$ )	P
Age (years)	25.5 (15–37)	27.5 (16–50)	NS
Follow-up (months)	24 (12–52)	22 (13–45)	NS
Female gender (%)	$n = 7$ (50%)	$n = 9$ (64%)	NS
Numbers of dislocations	$n = 3$ (2–9)	$n = 4$ (2–11)	NS
Flexion (°)	132 (125–140)	127 (120–130)	0.023
Lille score [5]	$54 \pm 13$ (34–76)	$48 \pm 15$ (26–82)	NS
IKDC score [6]	$58 \pm 10$ (42–77)	$50 \pm 12$ (27–67)	NS
ATT lowering	8	6	NS
ATT medialization	4	3	NS
ATT medialization and lowering	2	5	NS

ATT: anterior tibial tuberosity; NS: non-significant.



**Fig. 3.** T2-weighted fat-sat axial MRI slice at 38 months' follow-up in a 29-year-old man, showing 1.5 cm<sup>2</sup> Outerbridge grade 2 cartilage lesion [12] of the medial side of the patella.

Preoperative and follow-up radiographic assessment comprised lateral knee weight-bearing view in 30° flexion and axial Merchant view in 30° flexion. Patellar height was measured by Caton-Deschamps Index [10], severity of trochlear dysplasia was assessed following Dejour et al. [2], and patellofemoral osteoarthritis was quantified following Iwano et al. [11].

At follow-up, patellar height and patellofemoral compartment cartilage status were systematically assessed on 1.5 T MRI and compared to the 25 preoperative MRI scans (3 scans missing) (Fig. 3), using a 3D spoiled gradient recalled echo sequence (3D SPGR), on OsiriX™ freeware (OsiriX Foundation, Geneva, Switzerland). Lesions were isolated, touching the patellar surface (distinguishing medial or lateral side or patellar crest) or the trochlear surface (lateral edge and trochlear groove), or kissing lesions involving both patella and femoral trochlea. Ulcerated lesions and cartilage fissures were assessed on the Outerbridge classification [12] (Fig. 3), and osteochondral lesions on the Anderson classification [13].

### 2.3. Statistical analysis

Statistical analysis used SAS 9.3 software (SAS, Cary, NC). Qualitative data were expressed as numbers and percentages, and numerical data as means, standard deviations and ranges. Normal distribution of quantitative data was checked on Shapiro-Wilk test. Qualitative data were compared on McNemar's test of symmetry. Numerical data were compared on matched Student or Wilcoxon tests. Groups were compared on qualitative parameters by Fisher exact test and on quantitative parameters by Mann-Whitney U test. First-order risk was set at 5%.

## 3. Results

### 3.1. Patellofemoral stability

At a mean 24 months' follow-up (range, 12–52 months), there was no recurrence of patellar dislocation, but 5 patients (5 knees) (18%) showed episodic subjective instability with positive Smillie sign: 3 knees (21.4%) in the S– group (2 non-dysplastic and 1 grade A), and 2 knees (14.3%) in the S+ group (both grade D).

### 3.2. Functional results

Self-assessment showed 85.7% satisfaction (22 out of 26 patients, with 2 patients disappointed in either group). At

follow-up, functional scores showed significant improvement in both groups ( $P < 0.0001$ ). There was no significant inter-group difference in Lille score gain ( $P=0.492$ ) or mean ( $P=0.381$ ) at follow-up (Table 2). IKDC score gain was lower in the S+ group than in the S– group ( $P=0.031$ ), as was mean IKDC score at follow-up ( $P=0.012$ ) (Table 3). Mean flexion fell from  $132 \pm 4^\circ$  (range, 125–140°) to  $129 \pm 10^\circ$  (range, 110–140°) in the S– group, and from  $127 \pm 6^\circ$  (range, 120–140°) to  $125 \pm 8^\circ$  (range, 125–140°) in the S+ group (NS).

### 3.3. Complications

Complications occurred in 5 of the 28 knees (17.8%) (Table 4). Two S– knees (14.3%) and 2 S+ knees (14.3%) showed stiffness in flexion requiring surgical mobilization under general anesthesia; there was no residual stiffness.

One patient without dysplasia showed persistent irreducible extension loss; he had developed acute operative site *Staphylococcus epidermidis* infection, requiring surgical revision by lavage and antibiotherapy, followed by mobilization under general anesthesia for stiffness in flexion 6 weeks after the lavage.

Thus, in all, the surgical revision rate was 5/28 (17.8%): 4 mobilizations under general anesthesia, and 1 lavage; there was no significant inter-group difference in complications (Table 4).

### 3.4. Imaging and cartilage assessment

At follow-up, Caton-Deschamps index and patellar tilt had normalized in both groups (Tables 5 and 6), with no significant difference between groups pre- or post-operatively.

Three knees (10.7%) showed Iwano grade 1 radiographic signs of patellofemoral osteoarthritis on Merchant view, pre-operatively and at follow-up: 2 S+ knees (both grade D) and 1 S– knee (grade A).

Table 7 shows the distribution of cartilage lesions on MRI. There were significantly more preoperative lesions in the S+ group. There was a strong predominance of isolated lesions preoperatively ( $n=15/19$ , 79%) and at follow-up ( $n=19/23$ , 83%). Locations were mainly on the patellar crest: 14/15 (93%) preoperatively, and 15/19 (79%) at follow-up. There were also significantly more cartilage lesions in the S+ group at follow-up ( $P=0.047$ ), and these were more severe: 12/14 (86%) grade  $\geq 2$  versus 5/9 (56%) in the S– group ( $P=0.026$ ). There was no significant inter-group difference in cartilage lesion progression (Table 7).

## 4. Discussion

The study hypothesis was not confirmed: clinical functional results were poorer in the S+ group, with lower mean IKDC score. This seems mainly due to the higher rate of preoperative cartilage lesions in that group, rather than to surgical technique. There was, however, no significant intergroup difference in Lille score, which focuses on stability [5]. Other studies reported negative impact of dysplasia severity on functional results after patellofemoral reconstruction [14–17], but the present study was the first case-control comparative analysis of such results. There was, on the other hand, no short-term recurrence of dislocation despite the presence of trochlear spurs, and patellar tilt was in most cases corrected. Nevertheless, subjective instability persisted in 5 cases (18%), which was comparable to the findings displayed in Table 8. The complications rate was acceptable, and lower than the 26.2% reported in the meta-analysis by Song et al. [9].

The study involved certain limitations: it was retrospective, but with complete data files except for 3 missing MRI scans. Follow-up was short (mean, 23 months), and the results need confirming in

**Table 2**  
Mean Lille Stability Score.

	Preoperative	Follow-up	Gain
Whole series	51 ± 14 (26–82)	82 ± 15 (39–97)*	30 ± 16 (–9–63)
S– (without trochlear spur)	54 ± 13 (34–76)	84 ± 15 (39–97)*	30 ± 17 (–9–51)
S+ (with trochlear spur)	48 ± 15 (26–82)	79 ± 16 (46–97)*	31 ± 16 (7–63)
P value, S– vs. S+	NS	NS	NS

\*Significant improvement at follow-up over preoperative status.

**Table 3**  
Mean IKDC Functional Score.

	Preoperative	Follow-up	Gain
Whole series	54 ± 11 (27–77)	74 ± 17 (21–92)*	20 ± 15 (–21–52)
S– (without trochlear spur)	58 ± 10 (42–77)	79 ± 19 (21–92)*,‡	21 ± 16 (–21–42)*
S+ (with trochlear spur)	50 ± 12 (27–67)	68 ± 13 (35–84)*	18 ± 14 (0.5–52)
P value, S– vs. S+	NS	0.0123	0.0186

\*Significant improvement at follow-up over preoperative status ( $P < 0.05$ ); ‡Significantly greater improvement in S+ group ( $P < 0.05$ ).**Table 4**  
Complications at follow-up per group.

	S– (without trochlear spur)	S+ (with trochlear spur)	P
Stiffness in flexion	2 (14.3%)	2 (14.3%)	NS
Stiffness in extension	1 (7%)	0	NS
Septic arthritis	1 (7%)	0	NS
Scar pain	1 (7%)	1 (7%)	NS
Deep venous thrombosis	0	1 (7%)	NS

**Table 5**  
Change in Caton-Deschamps Index.

	Preoperative		Follow-up	
	CDI	CDI > 1.2	CDI	CDI > 1.2
S–	1.25 ± 0.24 (0.75–1.52)	n = 10 (71%)	1.02 ± 0.2 (0.6–1.26)	n = 2 (14%)
S+	1.29 ± 0.18 (0.87–1.60)	n = 11 (78%)	1.06 ± 0.13 (0.75–1.6)	n = 1 (7%)
Difference S– vs. S+	NS	NS	NS	NS

CDI: Caton-Deschamps Index; S–: without spur; S+: with spur.

the longer term; the study, however, was intended to assess the short-term impact of dysplasia severity on MPFL reconstruction with ATTT, and as such was able to test the hypothesis. Numbers were small, and preoperative IKDC scores, although comparable between groups, showed a tendency to be poorer in the S+ group, probably due to cartilage lesions, and a larger sample might have disclosed a significant difference. On the other hand, regardless of

numbers, the association of ATTT and MPFL reconstruction significantly improved functional scores in the S+ group, with no recurrence of dislocation.

Despite the lack of progression of patellofemoral radiographic osteoarthritis and effective PFI correction by MPFL reconstruction, cartilage lesions continued to progress over the short term. It would thus seem that late treatment after iterative PFI fails to protect the

**Table 6**  
Change in patellar tilt on MRI.

	Preoperative		Follow-up		P
	Patellar tilt	Patellar tilt > 20°	Patellar tilt	Patellar tilt > 20°	
S–	22.8 ± 8.9 (10–46)	n = 9 (64%)	18.8 ± 6.1 (8–27)	n = 3 (21%)	0.0074
S+	23.7 ± 12.3 (10–51)	n = 11 (78%)	19.7 ± 9.3 (3–31)	n = 4 (28%)	0.0009
Difference S– vs. S+	NS	NS	NS	NS	

S–: without spur; S+: with spur.

**Table 7**  
Cartilage lesion assessment and evolution on MRI.

	Chondral lesions Preoperative	(Outerbridge [12]) Follow-up	Osteochondral lesions Preoperative	(Anderson et al. [13]) Follow-up
Whole series	76% (n = 19/25)	82% (n = 23/28)	32% (n = 9/25)	29% (n = 8/28)
S–	58% (n = 7/12)*	64% (n = 9/14)**	25% (n = 3/12)*	7% (n = 1/14)**
S+	92% (n = 12/13)**	100% (n = 14/14)**	46% (n = 6/13)*	50% (n = 7/14)**

S–: without spur; S+ with spur.

\*Significant preoperative difference between S– and S+; \*\*Significant difference between S– and S+ at follow-up.



**Table 8**

Clinical results in series of objective patellar instability managed by MPFL reconstruction.

Study	Number of knees	Follow-up (months)	Results (postoperative)	Subjective instability (at follow-up)
Hooper et al. [14]	68	38	Improved IKDC (76.2), Lysholm (73.3) and Tegner scores (3.6)*	n = 12 (17.6%)
Schöttle et al. [15]	48	12	Improved IKDC, Lysholm and Tegner scores	n = 5 (10.4%)
Wagner et al. [16]	49	12	Improved Kujala (87) and Tegner scores (4.6)*	n = 6 (12.2%)
Present series	28	24	Improved Lille (82) and IKDC scores (74)*	n = 5 (17.8%)

\*Results less good for dysplasia with spur.

cartilage even if PFI is corrected; this, of course, needs confirming over the longer term, with comparison to a non-operated control group.

The rate of cartilage lesions in the S+ group was higher than in the MRI studies by Elias et al. [17] (up to 80% in 82 knees) and Guerrero et al. [18] (49% in 195 knees). This may be due to the prevalence of supratrochlear spurs in the present series, not taken into account in the earlier morphologic studies [17,18]. This explanation is supported by the results in 304 knees reported by Jungmann et al. [19], with a significantly higher rate of cartilage lesions on MRI in the 85 knees with trochlear dysplasia. There was, however, a confusion bias in the present study, with numerous confounding factors that were not analyzed but might account for the onset of cartilage lesions.

## 5. Conclusion

In the present series, PFI treatment by MPFL reconstruction with ATTT provided good patellar stability in the short term, independently of the severity of trochlear dysplasia, but IKDC functional results and gains were poorer in case of dysplasia with trochlear spur. This was probably due to cartilage lesions, which were more frequent pre- and post-operatively in the S+ group, especially as there was no significant difference in Lille score, which focuses on stability.

## Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article. Otherwise, Henri Migaud works as an education and research consultant with Zimmer and Tornier, and Gilles Pasquier as an education and research consultant with Zimmer.

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